Are The Beatles Different? A Computerized Psychological Analysis of Their Music

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ABSTRACT: There has been little quantitative research by psychologists concerning the music of The Beatles. The present research compared their music against a database of 169,909 songs for which data was obtained via the Spotify application programming interface concerning acousticness, danceability, duration, energy, key, loudness, mode, popularity, tempo, and valence. The Beatles' music differed from the overall dataset by being more positively-valenced, more energetic, faster, louder, less acoustic, and shorter; and differed from their 1960s contemporaries by being more danceable, energetic, faster, louder, less acoustic, and shorter. Of these, only the loudness and valence of The Beatles' music was related positively to its popularity. The Beatles were able to avoid the overall trend for distinctive music to be less commercially successful, suggesting that they were able to innovate without sacrificing popularity. However, on further analysis, The Beatles' music was no more innovative (defined in terms of musical differences from other music) than that of their contemporaries for each year of the 1960s except 1969. The ongoing public acclaim of The Beatles can therefore be attributed to their music being louder and more emotionally positive, being no more musically-innovative than their peers, but when they did innovate, being relatively successful compared to their peers.

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MORE than 50 years have passed since the release of the final original studio album by The Beatles. Although the height of Beatlemania has subsided, their music continues to enjoy massive popular and critical acclaim. We concur with the view of veteran British broadcaster Danny Baker that, given their long-term cultural significance, The Beatles receive surprisingly little attention. Beatlesology exists as an identifiable component of musicology (e.g., Everett, 1999), but quantitative investigations of the psychological factors explaining the broad appeal of The Beatles are uncommon, with extensive focus instead on factors relating to music theory and audience reactions to particular tracks or albums.

This is particularly surprising in light of the recent trend in research, which employs large music databases to identify temporal trends or structural factors that predict various indices of popularity (e.g., Gauvin, 2015; Interiano et al., 2018; Kim, 2021; North et al., 2018; Schellenberg & von Scheve, 2012; Serra et al., 2012). Much of this has been reported in a diverse range of journals representing computer science, marketing, and psychology. Some of this research has represented arguably 'stand alone' works that seek to develop computer algorithms that might be used in music streaming over the internet, whereas other studies have employed well-established theories from the field of music psychology, which has a strong quantitative focus (e.g., Cook, 2021; Hallam, Cross, & Thaut, 2014; Juslin & Sloboda, 2010; North & Hargreaves, 2008). Several studies have used quantitative data derived from the application programming interface of the Spotify music streaming service (e.g., de Fleurian & Pearce, 2021; Stachi, Au, & Schoedel et al., 2020). Moreover, existing psychological research has focused on variables that were also addressed in the present research such as affect/valence (e.g., Juslin & Sloboda, 2010), aspects of music that evoke psychobiological arousal such

as energy, tempo, danceability, and loudness (e.g., Berlyne, 1971), and the extent to which a given piece of music is typical of the corpus as a whole (e.g., Martindale & Moore, 1989).

An imperfect but nonetheless striking illustration of the neglect of The Beatles can be seen by a database search. A PsycINFO search on 6 January 2022 produced 52 articles containing 'The Beatles' in the abstract, whereas a comparable search for other musical 'greats' gave rise to a greater number of hits: 'Mozart' produced 352 hits, 'Bach' received 368 hits, and 'Beethoven' produced 143 hits. We have to slip as far down the ladder of prestige as Brahms with 48 hits before we reached a comparable degree of psychological research interest to that concerning The Beatles (note that consideration of pop/rock music greats other than The Beatles is even more scarce). Moreover, of those articles indexed in PsycINFO that do mention The Beatles, a significant number simply used their music as an experimental stimulus (e.g., North, Hargreaves, & McKendrick, 1999; Rashotte & Wedell, 2012) or which otherwise did not concern the band per se. Indeed, only 18 articles mention 'The Beatles' in the title itself. Of course, the same point can be made concerning other composers and broadening the search terms to include 'Lennon' or 'McCartney' increases the number of hits. Nonetheless, it remains a valid point that very little psychological research has attempted a quantitative analysis of arguably the most successful musicians in history.

Of those few studies that do take an overtly quantitative psychological approach to The Beatles, several concern compositional teamwork and competitiveness between John Lennon and Paul McCartney, the band's two principal songwriters (e.g., Clydesdale, 2006; Glassman, 2008; Jackson & Padgett, 1982; Kopp, 2002). A small number of others focus on developmental issues, such as Taylor's (1966) remarkably far-sighted study of the personality correlates of engaging in Beatlemania, showing no relationship between this and hysteria or neuroticism. Santiago (1969) similarly considered how their fame meant that the music of The Beatles could be used in psychotherapy with adolescents. A small number of other psychologists have adopted a psychoanalytic or counselling approach to either the band members or their music (Brog, 1995, Deschenes, 2016).

However, there may be only two previous psychological papers that have attempted a quantitative analysis of The Beatles' music as a whole. First, Petrie et al. (2008) conducted a computerized analysis of the lyrics of 185 of the band's songs, including all those composed by John Lennon, Paul McCartney, and George Harrison. Among their findings, Petrie et al. report that, "songs from the early years of the Beatles were characterized by positive emotion," before becoming more melancholic from the 1965 release of the Help! album, and that the lyrics "became more complex and intellectual over time" (p. 200).

Second, West and Martindale (1996) analyzed The Beatles' lyrics in the context of a theory of artistic evolution, 'the clockwork muse,' which was itself based on Berlyne's (1971) highly influential psychobiological theory of aesthetics. West and Martindale argue that the audience for art works habituates over time, so that artists must present them with ever greater levels of stimulation and arousal in order to maintain interest. Eventually, all the possibilities for increasing stimulation (e.g., louder, brighter, larger, more complex) become exhausted, and so artists must develop new genres which represent stylistic evolution. Consistent with this, West and Martindale showed that, over time, there was an increase in The Beatles' use of diverse language, longer words, and 'primordial content' indicative of novel associations between words and concepts, all of which suggest attempts to provide increasing stimulation and arousal for their audience. In a similar vein, West and Martindale (1996) also summarize the results of a companion study concerning The Beatles' music specifically, stating that this "demonstrated monotonic increases in melodic originality, the use of rare, off-scale notes, and the use of uncommon note-to-note transitions across a chronological list of their songs" (p. 107). Again, this is consistent with the notion of the band striving to maintain the attention of their audience by producing ever more stimulating music.

Although not concerning The Beatles per se, we should also highlight another theory developed by Martindale in this context. Martindale and Moore (1989) argue that although audience habituation compels musicians to evolve and produce ever-more stimulating music, this may have repercussions for the popularity of that music. Martindale is one of several theorists who have argued that the public should prefer typical music, as it is easier to categorize and process than atypical music. Several studies provide varying degrees of support for this claim (e.g., Martindale & Moore, 1989; Martindale et al., 1988, 1990; North et al., 2017, 2019), sometimes proposing curvilinear components towards the tails of these relationships, such as Simonton's (1987) finding of a 'backwards inverted-J' relationship between melodic originality and the popularity of Beethoven's music (see also Hass, 2016). In pragmatic terms, this means that the more a given song differs from others so the less popular it should be.

Given that one component of The Beatles' legacy concerns their reputation for innovation (e.g., Everett, 1999), it follows that it would be interesting to investigate the extent to which their music differs

from that of others, and to relate this degree of difference to the popularity of the music in question. As such, the present research defines innovativeness as the extent to which a given song has musical features that are typical (i.e., less innovative) or untypical (i.e., more innovative) of the corpus as a whole by considering factors such as energy, loudness, and duration. Innovativeness as defined here therefore captures how much a given song differs from others in terms of various musical properties and avoids any preconceived notion of the more specific features that an 'innovative' piece of music must possess. Although operationalized differently, the principle is conceptually very similar to Simonton's (1980) measure of melodic originality, which calculated the statistical probability of the two-note transitions contained within the initial six notes of a melodic theme relative to the corpus as a whole, so that statistically improbable transitions lead to a particular theme being labelled as highly original.

Taken at face value, the existing theorizing by Martindale and colleagues implies that the more innovative (i.e., different or atypical) a song is, the less popular it should be. If The Beatles were indeed innovative musicians, then might this innovation have reduced their popularity? North et al.'s (2019) analysis of 204,000 pieces of music showed that slightly atypical music was more successful commercially than typical music, suggesting that The Beatles' innovativeness may instead have contributed to their popularity. Another interesting aspect of North et al.'s finding is that commercial success of the 204,000 pieces was negatively associated with artificial intelligence assessment of the music as relaxing, passionate, sad, and mysterious, and positively associated with assessment of the music as energetic. Is the music of The Beatles similarly more upbeat and stimulating, and can this help to explain its popularity? Note that popularity concerns commercial success, which in the case of the present research is defined in terms of the number of online streams of each track. This is distinguished from innovation, which is defined here in terms of the extent to which a song differs from others or critical acclaim.

The existing research findings are fascinating for any fan of The Beatles, but the lack of psychological evidence is disappointing for a number of reasons. First, there are numerous theories of musical taste. The cultural significance of The Beatles means it is arguably important that psychological variables can explain the success of the band. However, in this context, we are also aware that psychological evidence typically attempts to explain most instances of an attitude or behaviour most of the time, rather than necessarily all instances all of the time. The Beatles are outliers, and so it is interesting to investigate the extent to which the variables that explain musical taste in general can also explain the popularity of the band.

Second, the research that does exist leads to several subsequent questions. Most significantly, we do not know if or how the music of The Beatles differed from that of others in terms of variables of interest to psychologists. Is it positively-valanced, energetic, and innovative? If so, is it more positive, energetic, and innovative than other pop music or the music of The Beatles' contemporaries, and does this help to explain the popularity of The Beatles? Similarly, how does the music of The Beatles differ from that of others in terms of variables studied by psychologists interested in aesthetics, and how do any differences relate to the enduring popularity of the band?

The advent of commercial music streaming services makes it possible to address these questions. One such service, Spotify, has an application programming interface (API) which specifically allows the public to obtain meta-data concerning tracks offered by the service. Several of these variables within the Spotify API clearly map on to those studied conventionally in psychological research on musical taste. Most notably, musical features that have been identified in experimental aesthetics research as those which would stimulate and arouse the audience include energy, loudness, and tempo (cf. Berlyne, 1971; West & Martindale, 1996). Other variables are also clearly related to the present research, notably measures of valence and popularity as well as other variables relating to overtly musical properties, namely key, mode, duration, 'acousticness', and 'danceability'. These variables allow researchers to quantify the extent to which The Beatles' music differs from the music of others, and so determine the extent to which it is innovative, with clear relevance to previous research by Martindale and others. While it is impossible to develop formal hypotheses concerning the relationships between these variables, given the lack of existing evidence and status of The Beatles as 'unusual', the analyses were guided by the following research questions:

1) (How) Does the music of The Beatles differ from that of other popular musicians?
2) (How) Does the music of The Beatles differ from that of contemporaries during the 1960s?
3) Which factors predict the popularity of songs by The Beatles?

4) What is the relationship between the innovativeness of The Beatles' music and its popularity, and to what extent is the music of The Beatles more innovative than that of their 1960s contemporaries?

METHOD

The research employed an existing third-party dataset downloaded from https://www.kaggle.com/ektanegi/spotifydata-19212020 on 13 December 2021. The data set was initially uploaded to the site by Etka Nagi and colleagues on 29 August 2020. It contains information on 169,909 songs from 1921 to 2020 collated using the Spotify Web API. It includes the most popular 1000-2000 songs for each year from 1945 as well as several hundred most popular songs for each year from 1921-1944 with the exceptions of 1921, 1922, and 1923 for which there is data for the most popular 128, 72, and 169 songs respectively. Summary statistics concerning the dataset are available at https://medium.com/@lucaschu/how-has-music-changed-diving-into-spotify-data-393c071b5941.

The data includes 413 tracks credited to The Beatles, including commercially-available alternate takes and remastered recordings in addition to the canonical versions of the tracks first released during the 1960s. Our analyses included all 413 Beatles tracks for several reasons. First, we would otherwise be forced to identify the canonical version of a given Beatles song, which itself is an extremely contentious subject (see, e.g., Rense, 2018) concerning whether the 'true' version of a given song can be found on a recording released during the 1960s or on the remixed and remastered 50th anniversary versions of albums released during the 2010s, which attempted to more accurately reflect the band's intentions at the time. For example, the reprise of Sgt. Pepper's Lonely Hearts Club Band featured on the 2017 re-release of the album contains much louder drums, since McCartney can clearly be heard to request this at the time of recording. Similarly, although remastering changes the nature of the sound on the recording, it is also important to remember that any given generation of fans will have been exposed to more than one version of the recording. For instance, the CD release of The Beatles' albums would have been commonly heard in the late 1980s and early 1990s, and so arguably represents the definitive mastering of the recordings for people who first encountered the music then. Each generation has its 'own' version of the recordings and it is very difficult to argue that any one of these should take precedence.

Second, it is similarly difficult to reliably differentiate the main canon of songs from the band's relatively obscure releases. For example, while we might have analyzed only those tracks to appear on The Beatles' albums, this would neglect tracks originally released only as singles. Had we decided to include singles in addition to original albums, we would then need to determine whether to include tracks released as the B-side of these. It is debatable whether some of the tracks this would capture have greater cultural significance than does a version of a classic Beatles album track that was remastered and released after 1970.

Finally, The Beatles' early albums in the United States differed from those released in the United Kingdom (with different titles and track listings) and different singles were selected for release in different countries. So, adopting a very strict definition of The Beatles' canon focusing solely on album tracks and the A-side of singles released during the 1960s would be highly contentious. Therefore, we adopted the more prudent approach of simply using every track credited to The Beatles within the dataset. Note also that since the dataset contains only the most popular songs from each year, this in effect limits the music considered to only those tracks deemed by the 21st century public to be particularly likeable, interesting, or important.

For each song in the dataset, values are calculated by Spotify for several algorithmically-derived variables, as defined in the Spotify Web API Developer guide (https://developer.spotify.com/documentation/web-api/reference/#/, under the heading for 'Get tracks audio features'). For the present study, we used the following values:

- Acousticness. A confidence measure from 0.0 to 1.0 of whether the track is acoustic. 1.0 represents high confidence that the track is acoustic.
- Danceability. Danceability describes how suitable a track is for dancing based on a combination of musical elements including tempo, rhythm stability, beat strength, and overall regularity. A value of 0.0 is least danceable and 1.0 is most danceable.
- Duration. The duration of the track in milliseconds.
- Energy. Energy is a measure from 0.0 to 1.0 and represents a perceptual measure of intensity and activity. Typically, energetic tracks feel fast, loud, and noisy. For

example, death metal has high energy, while a Bach prelude scores low on the scale. Perceptual features contributing to this attribute include dynamic range, perceived loudness, timbre, onset rate, and general entropy.

- Key. The key the track is in. Integers map to pitches using standard pitch class notation e.g., 0 = C, 1 = C♯/D♭, 2 = D, and so on.
- Loudness. The overall loudness of a track in decibels (dB). Loudness values are averaged across the entire track and are useful for comparing relative loudness of tracks. Loudness is the quality of a sound that is the primary psychological correlate of physical strength (amplitude). Values typically range between -60 and 0 db.
- Mode. Mode indicates the modality (major or minor) of a track, the type of scale from which its melodic content is derived. Major is represented by 1 and minor is 0.
- Popularity. Values are derived from streaming counts on Spotify and range from 0 to 100 so that higher scores indicate greater popularity. The data is therefore based on streaming by the date at which the data is downloaded via the API.
- Tempo. The overall estimated tempo of a track in beats per minute (BPM). In musical terminology, tempo is the speed or pace of a given piece and derives directly from the average beat duration.
- Valence. A measure from 0.0 to 1.0 describing the musical positiveness conveyed by a track. Tracks with high valence sound more positive (e.g., happy, cheerful, euphoric), while tracks with low valence sound more negative (e.g., sad, depressed, angry).

As noted above, the innovativeness of The Beatles' songs was calculated by determining the extent to which each song differed from others in the dataset in terms of the variables for which we have data. To achieve this, a series of data transformations was carried out for each track. First, Z scores were calculated for danceability, valence, energy, tempo, loudness, acousticness, and duration: these express each data point in terms of its standard deviation from the overall mean for the variable in question. Negative Z scores were then multiplied by -1 so that all the scores were positive and simply expressed the degree of difference from the mean (irrespective of whether the data point was higher or lower than the mean). The resulting values for each track for each of danceability, valence, energy, tempo, loudness, acousticness, and duration were then summed. This summed value represented an overall difference score that quantifies the extent to which each track was different from the overall dataset. These difference scores for each track were then used in a series of further analyses.

RESULTS AND DISCUSSION

Comparison of The Beatles' Music with the Entire Dataset

All analyses were conducted using SPSS v26. A one-way MANOVA compared music by The Beatles against that of the remainder of the dataset on scores for danceability, valence, energy, tempo, loudness, acousticness, and duration. Use of a MANOVA reduces the possibility of a Type 1 error in cases where multiple outcome variables may be correlated. The result of this was significant, $F(7, 169901) = 42.15$, $p < .001$. Table 1 indicates significant differences between The Beatles and the remaining dataset on each of the variables except danceability, so that music by The Beatles was more positively-valenced, more energetic, faster, louder, less acoustic, and shorter. Note the very small effect sizes, but the results support the popular notion that The Beatles differ from others in that they are more positive and 'rock more.'

Two chi-square tests were used to determine whether key and mode respectively were associated with whether a piece of music was released by The Beatles. The result concerning key was statistically significant, $\chi 2$ (11) = 99.33, $p < .001$, $V = .007$. Observed and expected frequency counts are shown in Table 2. This indicates that music by The Beatles was more likely than we might expect to be in the keys of C, D, E, G, and A, and less likely than we might expect to be in the remaining keys (including notably F and B). It is tempting to speculate that this might be because C, D, E, G, and A lend themselves more easily to being played on guitar, the main instrument used by The Beatles in performance and arguably composition (and perhaps music by any guitar-based band is more likely to be in these keys). The Fisher's exact text concerning mode was statistically significant, $\chi 2$ (1) = 25.27, $p < .001$. Observed and expected frequency counts are

shown in Table 3. Calculation of the odds ratio shows that the overall dataset was 1.89 times more likely than music by The Beatles to use a minor key. More simply, music by The Beatles was less likely to be in a minor key and this is consistent with the results of the MANOVA concerning the positive, upbeat nature of the music. These results are consistent with North et al.'s (2019) finding from 204,000 pieces that upbeat, stimulating music is more popular, and suggests that this may underlie the popularity of The Beatles. We return to this point shortly, however, when explicitly considering data on popularity.

Table 1. Difference between The Beatles and the overall dataset on continuous variables

	Dataset Mean (SD)	Beatles Mean (SD)	*F*	*p*	Eta squared
Danceability	0.54 (.18)	0.52 (.14)	3.24	.072	0.0000
Valence	0.53 (.26)	0.62 (.25)	44.84	<.001	0.0002
Energy	0.49 (.27)	0.55 (.20)	19.85	<.001	0.0001
Tempo	116.94 (30.73)	121.08 (27.24)	7.49	.006	0.0000
Loudness	-11.37 (5.67)	-9.68 (2.81)	36.80	<.001	0.0002
Acousticness	0.40 (.38)	0.36 (.28)	51.52	<.001	0.0003
Duration	231545.13 (121401.87)	174371.56 (59184.31)	91.55	<.001	0.0005

Note. Degrees of freedom = 1,169,907 in all cases

Table 2. Frequency of key used by The Beatles compared to overall dataset

		Dataset	Beatles
C	Observed	21419.0	80.0
	Expected	21446.7	52.3
C♯/D♭	Observed	12794.0	2.2
	Expected	12784.8	31.2
D	Observed	18760.0	61.0
	Expected	18775.3	45.7
D♯/E♭	Observed	7180.0	5.0
	Expected	7167.5	17.5
E	Observed	12860.0	61.0
	Expected	12889.6	31.4
F	Observed	16313.0	23.0
	Expected	16296.3	39.7
F♯/G♭	Observed	8570.0	16.0
	Expected	8565.1	20.9

G	Observed	20701.0	56.0
	Expected	20706.5	50.5
G♯/A♭	Observed	10702.0	9.0
	Expected	10685.0	26.0
A	Observed	17573.0	55.0
	Expected	17585.2	42.8
A♯/B♭	Observed	12042.0	14.0
	Expected	12026.7	29.3
B	Observed	10582.0	11.0
	Expected	10567.3	25.7

Table 3. Frequency of mode used by The Beatles compared to overall dataset

		Dataset	Beatles
Minor	Observed	49445.0	74.0
	Expected	49398.6	120.4
Major	Observed	120051	339.0
	Expected	1200097.4	292.6

Comparison of The Beatles with Contemporaries

The above analyses were then repeated to compare music by The Beatles with other music released from 1962-1970 inclusive (n = 17,713). A one-way MANOVA compared music by The Beatles against that of their contemporaries on scores for danceability, valence, energy, tempo, loudness, acousticness, and duration. The result of this was significant, $F(7, 17992) = 29.40$, $p < .001$. Table 4 indicates significant differences between The Beatles and their contemporaries on each of the variables except valence, such that music by The Beatles was more danceable, energetic, faster, louder, less acoustic, and shorter. Note that while The Beatles have a more positive valence than the dataset as a whole (see Table 1), Table 4 shows that they are not more positively-valenced than their contemporaries from 1962-1970. Again, the effect sizes are small, but the data indicates that music by The Beatles did 'rock more' than their contemporaries.

Two chi-square tests were carried out on music released from 1962-1970 to determine whether key and mode respectively were associated with whether a piece of music was released by The Beatles. The result concerning key was statistically significant, $\chi 2$ (11) = 54.33, $p < .001$, $V = .017$. Observed and expected frequency counts are shown in Table 5. This indicates that music by The Beatles was more likely than we might expect to be in the keys of C, D, E, and A, and less likely than we might expect to be in the remaining keys (including notably C, F, and B). Note that unlike the comparison with the dataset as a whole, the comparison here between The Beatles and their contemporaries shows that they were not more likely than we might expect to compose in G. Otherwise, the results again suggest that The Beatles appeared to be more likely than their contemporaries to favor keys that are easier to play on the guitar. The Fisher's exact text concerning mode was statistically significant, $\chi 2$ (1) = 4.10, $p = .045$. Observed and expected frequency counts are shown in Table 6. Calculation of the odds ratio showed that their 1960s contemporaries were 1.36 times more likely to use a minor key than were The Beatles. Although the MANOVA result concerning valence specifically (see Table 4) was not significant, the lower propensity of The Beatles to employ minor

keys relative to their contemporaries provides some evidence that their music was relatively uplifting for the period.

Table 4. Differences between The Beatles and 1960s contemporaries on continuous variables

	1962-1970 Mean (*SD*)	Beatles Mean (*SD*)	*F*	*p*	Eta squared
Danceability	0.50 (.15)	0.53 (.15)	9.03	.003	0.0005
Valence	0.57 (.25)	0.59 (.25)	3.04	.081	0.0002
Energy	0.44 (.23)	0.53 (.19)	41.74	<.001	0.0023
Tempo	116.24 (29.54)	120.10 (27.09)	4.84	.028	0.0003
Loudness	-12.41 (4.75)	-10.03 (2.88)	71.38	<.001	0.0040
Acousticness	0.58 (.30)	0.37 (.29)	128.74	<.001	0.0071
Duration	211899.61 (126300.95)	173217.34 (60023.92)	26.82	<.001	0.0015

Note. Degrees of freedom = 117,998 in all cases

Table 5. Frequency of key used by The Beatles compared to 1960s contemporaries

		1962-1970	Beatles
C	Observed	2558.0	57.0
	Expected	2573.3	41.7
C♯/D♭	Observed	849.0	13.0
	Expected	848.3	13.7
D	Observed	2133.0	45.0
	Expected	2143.3	34.7
D♯/E♭	Observed	768.0	3.0
	Expected	758.3	12.3
E	Observed	1401.0	4.1
	Expected	1419.0	23.0
F	Observed	1975.0	17.0
	Expected	1960.2	31.8
F♯/G♭	Observed	566.0	11.0
	Expected	567.8	9.2
G	Observed	2356.0	36.0
	Expected	2353.9	38.1
G♯/A♭	Observed	972.0	7.0

	Expected	963.4	15.6
A	Observed	2039.0	41.0
	Expected	2046.8	33.2
A♯/B♭	Observed	1291.0	8.0
	Expected	1278.3	20.7
B	Observed	805.0	8.0
	Expected	800.0	13.0

Table 6. Frequency of mode used by The Beatles compared to 1960s contemporaries

		1962-1970	Beatles
Minor	Observed	4242.0	54.0
	Expected	4227.5	68.5
Major	Observed	13471.0	233.0
	Expected	13485.5	218.5

Popularity

An independent samples t-test showed unsurprisingly that The Beatles' tracks (M = 48.05, SD = 12.92) had higher popularity scores than did the remainder of the dataset (M = 31.52, SD = 21.58), t (169907) = 15.56, p < .001. A follow up analysis compared the popularity of The Beatles's tracks against only those tracks released from 2011 onwards (i.e., the most recent decade in the dataset), showing that The Beatles were significantly less popular than current music (t (20065) = 27.83, p < .001, M = 48.05 and 60.57 respectively, SD = 12.92 and 10.54 respectively). A multiple regression was then carried out on only The Beatles' songs to determine the extent to which popularity could be predicted by danceability, valence, energy, tempo, loudness, acousticness, and duration.

The resulting model explained 8.8% of the variance (F (7, 405) = 6.70, p < .001). The data in Table 7 in conjunction with Tables 1 and 4 show that the popularity of songs by The Beatles was related positively to their (relatively positive) valence and (relatively high) loudness and negatively to their (relatively high) danceability and (relatively high) energy. The popularity of songs by The Beatles was not related to their (relatively fast) tempo, (relatively low) acousticness, or (relatively short) duration. In summary, although The Beatles produced music that was more danceable, energetic, faster, more 'electric', and shorter (see Tables 1 and 4), these characteristics did not contribute positively to their popularity (see Table 7). The distinguishing characteristics of songs by The Beatles which also appear to explain their high popularity relative to the overall dataset are specifically their relatively positive valence and greater loudness. Other aspects of the songs of The Beatles either did not differ significantly from other music, or if they did differ, did not appear to increase the popularity of the songs in question. Note in particular that the greater danceability and energy scores of The Beatles appeared to detract from the popularity of their songs.

Table 7. Prediction of the popularity of The Beatles

	Beta	Standardised beta	*t*	*p*	95% CI	
					Lower bound	Upper bound
Danceability	-10.14	-0.11	-2.14	.033	56.18	86.68
Valence	9.82	0.19	3.01	.003	-19.45	-0.83
Energy	-16.45	-0.26	-3.33	.001	3.41	16.23
Tempo	0.00	0.00	0.02	.982	-26.19	-6.73
Loudness	1.38	0.30	4.32	<.001	-0.04	0.05
Acousticness	-4.83	-0.11	-1.84	.066	-9.98	0.32
Duration	-4.918e-07	-0.00	-0.04	.967	0.00	0.00

Difference Scores and Popularity

A further set of analyses considered how each individual track differed from the dataset as a whole, and the relationship between this difference score for each track and both popularity and year of release. First, we examined the relationship between difference scores and popularity through two product-moment correlations. The first correlation concerned this relationship across the dataset as a whole, whereas the second correlation concerned this relationship within music by The Beatles only. Across the dataset as a whole, difference scores were related negatively to popularity, r (169909) = -.15, p < .001. Although the effect was weak, different songs were less popular. However, there was no relationship between popularity and difference scores for music by The Beatles, r (413) = -.01, p = .80: whether a given song by The Beatles is innovative or derivative has no implications for its popularity. More simply, in the dataset as a whole, songs with high difference scores are less popular, whereas difference scores are not related to popularity in music by The Beatles.

When considered in conjunction, there are two possible interpretations of these correlations. First, it is possible that the public are more forgiving of The Beatles producing 'different' music. While different music was less popular across the overall dataset, the public appear to turn a blind eye to instances where The Beatles produced something 'different'. This leads to a second complementary interpretation of the two correlations here, which is that The Beatles may simply have been better at producing 'different' music. It is possible that when The Beatles innovated, they did so well enough that people still enjoyed it and the popularity of their songs was not attenuated.

This is particularly interesting in light of research cited above noting that atypical music ought to be less popular, so that the public prefers music that is meaningful and more similar to the musical corpus as a whole. The present findings confirm these arguments and observations across the dataset as a whole. Crucially though, the present findings do not support these arguments and observations within the music of The Beatles. More simply, the correlations between difference scores and popularity show that The Beatles were able to buck the trend of being punished by the market for innovating, and a further component of what makes The Beatles' music special may be their ability to innovate successfully.

Difference Scores by Year

We then conducted a second analysis of the difference scores in which we calculated the mean difference score by year for the dataset as a whole (excluding music by The Beatles) and then only for music by The Beatles. This second analysis highlights an important nuance to the earlier conclusion that The Beatles were able to innovate in ways that had no impact on the popularity of their music. In popular culture, The Beatles have arguably become synonymous with the notion of a rapid increase in musical innovation during the 1960s, particularly from a period beginning with the release of either Rubber Soul (December 1965) or Sgt Pepper (May 1967; e.g., Everett, 1999). At the risk of over-generalizing, the reputation of The Beatles is that

they were the spearhead of an experimental 1960s musical revolution that changed pop music from entertainment to an art form. In contrast, the second analysis of the difference scores suggests that The Beatles should not necessarily be afforded this status.

Table 8 shows difference scores by year for 1964 (i.e., before Rubber Soul) to 1970 for both The Beatles alone and also for the dataset as a whole (excluding songs by The Beatles). Two patterns are evident within Table 8. First, there is no evidence of an increase in The Beatles' innovativeness from 1964 to 1970 (although 1969 is an exception to this). This does not mean that they did not innovate, but rather that there was no increase in their propensity to do this. Second, comparing the data for The Beatles against that for the overall dataset shows that there is little or no difference between the two in any given year. Although Tables 1-6 show that the music of The Beatles differs significantly from that of others in terms of individual variables, Table 8 shows that in no given year did The Beatles' rate of innovation appear to outstrip that of their contemporaries. Indeed, 1969 is the only year in which the difference score for The Beatles is greater than the difference score for the overall dataset, indicating that in the remaining years, The Beatles were actually a little less innovative than their peers. Note also that the overall mean difference score for the dataset across all years was 5.61 (SD = 2.01), so that there is no year from 1964-1970 for either The Beatles or the overall dataset that particularly stands out as clearly groundbreaking. Of course, the fact that the difference scores were not 0 indicates that musical innovation certainly took place during the 1960s. However, 1964-1970 does not appear to be an especially innovative period and The Beatles do not stand out relative to the remainder of the cohort during this period. When viewed in light of the correlations concerning popularity and difference scores, the aspect of The Beatles' innovativeness that is discrepant from others is their ability to innovate without reducing the popularity of the songs in question, while generally producing music that was not groundbreaking compared to that of their contemporaries. We return to this point in the General Discussion.

Table 8. Difference scores by year

Year	Mean difference score for The Beatles	Mean difference score for overall dataset
1964	4.68	5.29
1965	4.55	5.09
1966	4.47	4.98
1967	4.47	4.79
1968	4.79	4.79
1969	5.07	4.97
1970	4.46	4.83

GENERAL DISCUSSION

The findings here show that the music of The Beatles differed from the overall dataset by being more positively-valenced, more energetic, faster, louder, less acoustic, and shorter, as well as differed from that of contemporaries by being more danceable, energetic, faster, louder, less acoustic, and shorter. Of these, only the greater loudness and more positive valence of the music of The Beatles were related positively to its popularity. The Beatles were able to buck the overall trend for distinctive music to be less commercially successful than derivative music, so that when they did innovate, they managed to do so without sacrificing commercial success. However, The Beatles' music was no more innovative than that of their contemporaries (except in 1969), at least when this is measured in terms of the variables captured by the Spotify API. The public acclaim of The Beatles can therefore be attributed to their music being louder and more emotionally positive, not being necessarily any more innovative than the music of their peers, but being relatively successful compared to their peers in the case of those songs which were more innovative.

Note that the effect sizes reported here are typically small and the large dataset obviously contributes to the number of significant findings reported here. This may explain why Tables 1-6 show that The Beatles' music differs from that of others, whereas Table 8 shows that overall these differences were small. Note that the songs against which The Beatles were compared to were diverse. The analyses show how the music of The Beatles differs from other very popular pieces, but it is possible that music by any performer would differ in some way from the corpus as a whole. On one hand, it could be argued that it is nonetheless interesting that the variables studied here are significantly related to the popularity of The Beatles, given the large number of other factors that presumably underlie the band's legacy. On the other hand, of course, these other factors were not studied within the present research and so their importance remains undetermined. Some of these other variables will concern subtle and complex aspects of the music, although it is entirely possible that there may be aspects of the music that are important to explaining The Beatles' legacy which could be captured quite easily but simply are not.

In this context, it is notable and unfortunate that the Spotify Developers Guide provides relatively little information concerning the calculation of the variables on which data is provided (presumably on grounds of commercial sensitivity). Given the number of research papers which are beginning to employ this data, there is a growing case for work that explicitly investigates the detail of these. For example, it is unclear how the Spotify data codes songs which start in one key and then modulate to another, and the lack of information provided concerning these variables makes it similarly difficult to understand the difference between mode and valence. The latter presumably captures factors beyond the former, but information concerning this is not in the public domain. Moreover, the lack of information concerning how the variables are calculated means that the present research had to assume that the data are reliable and valid. The dataset employed here is fascinating and better than nothing, but also far from ideal and at best opaque.

However, perhaps the greatest weakness of the present research is that computerized analysis of digital audio files of individual songs fails to capture a number of highly-innovative musical techniques with which The Beatles are associated with. Even though some of these are partly a product of more general technological and commercial innovation of the period, it would be interesting to determine quantitatively how much The Beatles were truly trailblazers in these respects. For example, the analysis of individual songs employed here does not capture innovations such as the development of the concept album. Sgt Pepper is commonly credited as inventing the concept album, which dominated the music of the 1970s. However, there are arguably several other Beatles releases which are also well-known for representing a single concept, such as the Magical Mystery Tour project, Let It Be (which the recent Peter Jackson documentary clearly shows was originally conceived as a live performance potentially by a third-party band, similar to Sgt. Pepper), and the suite of songs that ends Abbey Road. Similarly, computer analysis of digital audio files of individual songs does not capture other innovations which have surely played a role in establishing the artistic legacy of The Beatles. These include the use of the recording studio as an instrument (e.g., Tomorrow Never Knows), popularization of synthesizers (which are often quiet in the final mix of the songs that was released and so largely inaudible to the computer), and using short elements of avant garde (e.g., A Day in the Life) and Indian classical instrumentation and music (e.g., Within You, Without You). None of these features of the music of The Beatles has a strong (or in some cases any) impact on a computerized analysis, but they clearly are culturally significant.

Added to this is the commercial and industrial innovation which might well be attributable to The Beatles. Their commercial success in the United States, in particular, arguably transformed the music industry's view of 'pop music' from a potentially transient fad into something of longer-term, significant commercial opportunity. More generally still, the legacy of The Beatles surely to some extent is attributable to them establishing pop music as a viable form of art. Computerized analysis of digital song files simply cannot hear these aspects of the music and its cultural significance, or account for their potential to set The Beatles apart from other musicians. Future research will need to quantify the extent to which The Beatles were truly trailblazers in these respects and whether this relates to the short- and longer-term popularity of the band. In this context, it would also be useful to attempt to separate aspects of The Beatles' undoubted creative genius from the input of producer George Martin, and those numerous serendipitous factors that have also contributed to their legacy (e.g., Yesterday coming to Paul McCartney in a dream, the abrupt ending of She's So Heavy being caused by the tape running out, Her Majesty appearing as the last track on Abbey Road because it was accidentally left there on the tape by recording studio staff, or Paul McCartney recording the great guitar solo on Taxman simply because George Harrison was not around at the time).

The present research also pays no attention to a number of other factors that surely also play a role in the phenomenal success of the band. The most obvious omission from the present research concerns

analysis of The Beatles' lyrics. For example, it is difficult to imagine that the popularity of songs such as I Am The Walrus, Eleanor Rigby, Let It Be, or Happiness is a Warm Gun is unrelated to the lyrics of those songs. They provide rich imagery, pathos, emotional succor, and humor respectively, all of which are traits associated commonly with The Beatles that clearly derive as much from the lyrics as the music.

Moreover, beyond the recorded sounds and musical techniques of The Beatles are a host of sociocultural factors that at least deserve empirical investigation as predictors of the band's popularity. For example, the band members were undoubtedly very charismatic and entertaining interviewees. Recent innovations in artificial intelligence analysis of text, developed for analysis of social media posts, make it possible to analyze public comments by The Beatles in terms of how engaging they are, and so this could potentially relate their popularity. Similar big data techniques developed in recent years allow quantification of the extent to which The Beatles shaped or captured the broader, non-musical sociocultural zeitgeist of the 1960s. It may also be particularly informative to consider how the enduring legacy of The Beatles is attributable to snowballing popularity and normative influence.

In addition to these macro-level variables, it would also be very interesting if future research were to take a very micro-level approach. The present research highlights the ways in which the music of The Beatles is different to that of others. So, is it the case that music by other composers that shares similar values on these variables also enjoys a high level of popularity? More simply, do the ways in which the music of The Beatles is 'different' represent a formula of some sort that is associated with popularity? Similarly, it is notable that the present data shows that the relative popularity of The Beatles can be explained by variables that have been used in previous research to explain the popularity of other music. Note that the measure of innovativeness (i.e., the difference scores) used a different method than that used in previous research, and the measure of popularity employed here (namely streaming counts) is arguably more limited in scope than measures of 'liking' and similar used in previous research. It would be interesting to attempt to repeat the research reported here using more conventional definitions of popularity and typicality. It is less clear whether the evidence here concerning The Beatles can be taken as explicit support for those theories that identified these variables, given that The Beatles are outliers in terms of their high level of popularity. We look forward to conducting and reading research on subjects such as these.

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NOTES

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REFERENCES

Berlyne, D. E. (1971). *Aesthetics and psychobiology*. New York, NY: Appleton Century Crofts.

Brog, M. A. (1995). The phenomena of Pine's 'four psychologies': Their contrast and interplay as exhibited in the Beatles' 'White Album'. *American Journal of Psychotherapy*, *49*, 385–404. https://doi.org/10.1176/appi.psychotherapy.1995.49.3.385

Clydesdale, G. (2006). Creativity and competition: The Beatles. *Creativity Research Journal*, *18*, 129–139. https://doi.org/10.1207/s15326934crj1802_1

Cook, N. (2021). *Music: A Very Short Introduction (2nd edition)*. Oxford, UK: Oxford University Press. https://doi.org/10.1093/actrade/9780198726043.001.0001

de Fleurian, R. & Pearce, M. T. (2021). The relationship between valence and chills in music: A corpus analysis. *i-Perception, 12*(4). https://doi.org/10.1177/20416695211024680

Deschenes, G. (2016). The homo faber-religiosus-ludens as a spiritual model of leisure through the aging process: A post-secular illustration of three Beatles songs. *Counselling and Spirituality / Counseling et spiritualite*, *35*, 47–66.

Everett, W. (1999). *The Beatles as musicians*. New York, NY: Oxford University Press.

Gauvin, H. L. (2015). "The times they were a-changin'": A database-driven approach to the evolution of harmonic syntax in popular music from the 1960s. *Empirical Musicology Review*, *10*, 215–238. https://doi.org/10.18061/emr.v10i3.4467

Glassman, G. S. (2008). All you need is creativity: The Beatles' creative process. *Dissertation Abstracts International Section A: Humanities and Social Sciences*, *68*(11-A), 4537.

Hallam, S., Cross, I., & Thaut, M. H. (Eds.) (2014). *Oxford Handbook of Music Psychology (2nd edition)*. Oxford, UK: Oxford University Press. https://doi.org/10.1093/oxfordhb/9780198722946.001.0001

Hass, R. W. (2016). An exploration of the relationship between melodic originality and fame in early 20th-century American popular music. *Psychology of Music*, *44*, 710–729. https://doi.org/10.1177/0305735615590429

Interiano, M., Kazemi, K., Wang, L., Yang, J., Yu, Z., & Komarova, N. L. (2018). Musical trends and predictability of success in contemporary songs in and out of the top charts. *Royal Society Open Science*, *5*(5), 171274. https://doi.org/10.1098/rsos.171274

Jackson, J. M. & Padgett, V. R. (1982). With a little help from my friend: social loafing and the Lennon-McCartney songs. *Personality and Social Psychology Bulletin*, *8*, 672–677. https://doi.org/10.1177/0146167282084011

Juslin, P. N. and Sloboda, J. A. (Eds.) (2010). *Handbook of Music and Emotion: Theory, Research, Applications*. Oxford, UK: Oxford University Press.

Kim, J. (2021). Music popularity prediction through data analysis of music's characteristics. *International Journal of Science, Technology, and Society*, *9*, 239–244. https://doi.org/10.11648/j.ijsts.20210905.16

Kopp, D. M. (2002). Linking differences in self-directed learning competency to dyadic conflict: An instrumental case study of the leadership dyad of John Lennon and Paul McCartney. *Dissertation Abstracts International Section A: Humanities and Social Sciences*, *62*(9-A) , 2971.

Martindale, C., & Moore, K. (1989). Relationship of musical preference to collative, ecological, and psychophysical variables. *Music Perception*, *6*, 431–455. https://doi.org/10.2307/40285441

Martindale, C., Moore, K., & Borkum, J. (1990). Aesthetic preference: Anomalous findings for Berlyne's psychobiological theory. *American Journal of Psychology*, *103*, 53–80. https://doi.org/10.2307/1423259

Martindale, C., Moore, K., & West, A. (1988). Relationship of preference judgements to typicality, novelty, and mere exposure. *Empirical Studies of the Arts*, *6*, 79–96. https://doi.org/10.2190/MCAJ-0GQT-DJTL-LNQD

North, A. C. & Hargreaves, D. J. (2008). *The Social and Applied Psychology of Music*. Oxford, UK: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198567424.001.0001

North, A. C., Hargreaves, D. J. & McKendrick, J. (1999). Music and on-hold waiting time. *British Journal of Psychology*, *90*, 161–164. https://doi.org/10.1348/000712699161215

North, A. C., Krause, A. E., Sheridan, L. P., & Ritchie, D. I. (2017). Energy, typicality, and music sales: A computerised analysis of 143,353 pieces. *Empirical Studies of the Arts*, *35*, 214–229. https://doi.org/10.1177/0276237416688063

North, A. C., Krause, A. E., Sheridan, L. P., & Ritchie, D. I. (2018). Energy, popularity, and the circumplex: a computerised analyses of emotion in 143,353 musical pieces. *Empirical Studies of the Arts*, *36*, 127–161. https://doi.org/10.1177/0276237417704339

North, A. C., Krause, A. E., Sheridan, L. P., & Ritchie, D. I. (2019). Popularity, mood, energy, and typicality in music: a computerised analysis of 204,506 pieces. *Psychology of Aesthetics, Creativity, and the Arts*, *13,* 89–109. https://doi.org/10.1037/aca0000165

Petrie, K. J., Pennebaker, J. W. & Sivertsen, B. (2008). Things we said today: a linguistic analysis of the Beatles. *Psychology of Aesthetics, Creativity, and the Arts*, *2*, 197–202. https://doi.org/10.1037/a0013117

Rashotte, M. A. & Wedell, D. H. (2012). Context effects on tempo and pleasantness judgments for Beatles songs. *Attention, Perception, & Psychophysics*, *74*, 575–599. https://doi.org/10.3758/s13414-011-0255-y

Rense, Rip. (2018). Sgt. Pepper summer. *Psychological Perspectives*, *61*, 311–319. https://doi.org/10.1080/00332925.2018.1495510

Santiago, L. P. (1969). The lyrical expression of adolescent conflict in the Beatles' songs. *Adolescence*, *4*, 199–210.

Schellenberg, E. G., & von Scheve, C. (2012). Emotional cues in American popular music: five decades of the Top 40. *Psychology of Aesthetics, Creativity, and the Arts*, *6*, 196–203. https://doi.org/10.1037/a0028024

Serra, J., Corral, Á., Boguñá, M., Haro, M., & Arcos, J. U. (2012). Measuring the evolution of contemporary western popular music. *Nature: Scientific Reports*, *2*(521), 1–6. https://doi.org/10.1038/srep00521

Simonton, D. K.. (1980). Thematic fame and melodic originality: a multivariate computer–content analysis. *Journal of Personality*, *48*, 206–219. https://doi.org/10.1111/j.1467-6494.1980.tb00828.x

Simonton, D. K. (1987). Musical aesthetics and creativity in Beethoven: a computer analysis of 105 compositions. *Empirical Studies of the Arts*, *5*, 87–104. https://doi.org/10.2190/B94K-CP9N-VUT8-RLKH

Stachi, C., Au, Q., & Schoedel, R. Tell al. (2020). Predicting personality from patterns of behavior collected with smartphones. *Proceedings of the National Academy of Sciences of the United States of America*, *117* , 17680–17687. https://doi.org/10.1073/pnas.1920484117

Taylor, A. J. (1966). Beatlemania: a study in adolescent enthusiasm. *British Journal of Social & Clinical Psychology*, *5*, 81–88. https://doi.org/10.1111/j.2044-8260.1966.tb00958.x

West, A., & Martindale, C. (1996). Creative trends in the content of Beatles lyrics. *Popular Music and Society*, *20*, 1–8. https://doi.org/10.1080/03007769608591647